

# Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB05/000536

International filing date: 15 February 2005 (15.02.2005)

Document type: Certified copy of priority document

Document details: Country/Office: GB  
Number: 0406168.5  
Filing date: 19 March 2004 (19.03.2004)

Date of receipt at the International Bureau: 08 April 2005 (08.04.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



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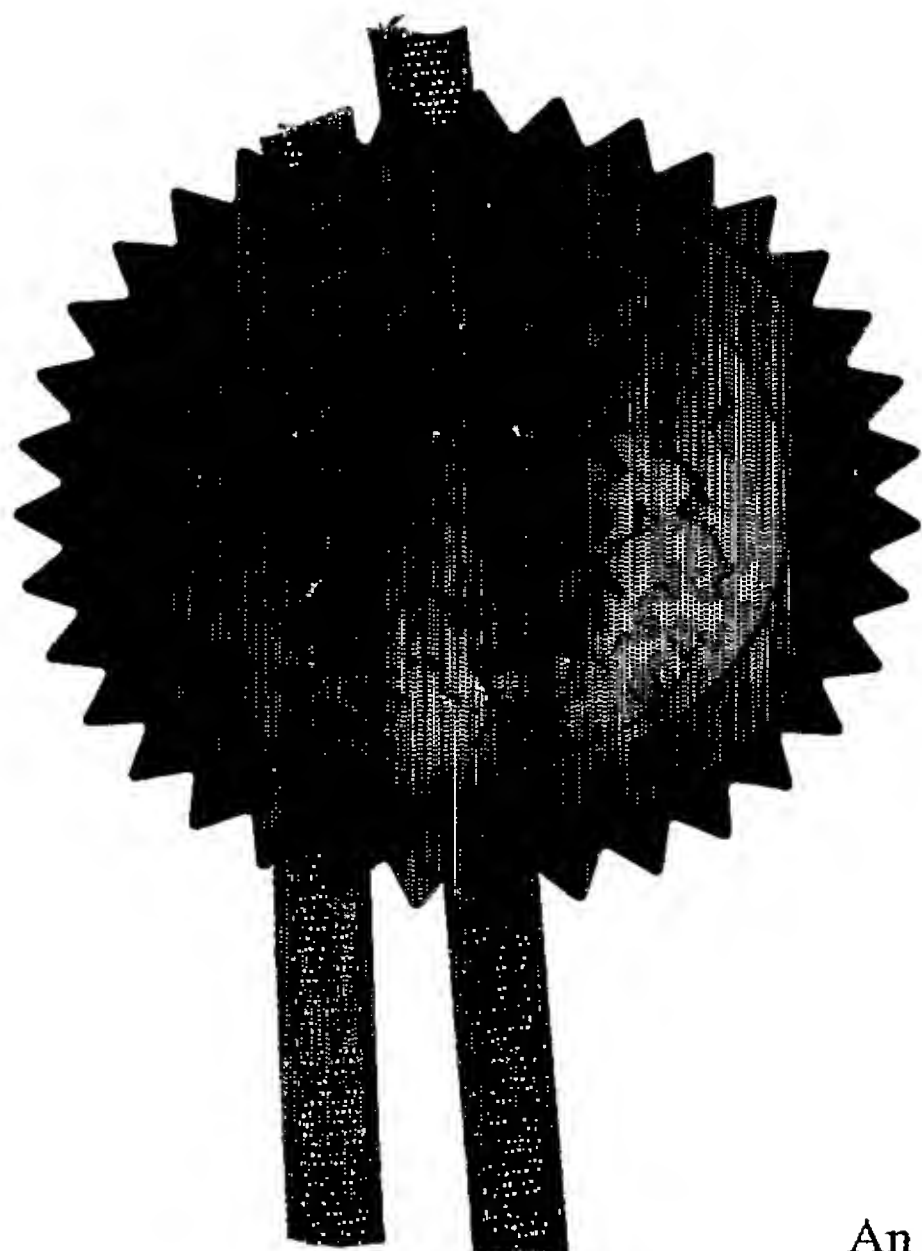
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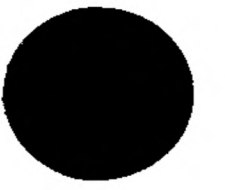
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Patents ADP number (*if you know it*)

60 The Crest  
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If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

08832545001

4. Title of the invention

HIGH PRESSURE PUMPING APPARATUS AND METHODS

5. Name of your agent (*if you have one*)

SOMMERVILLE & RUSHTON

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Claim(s) 2

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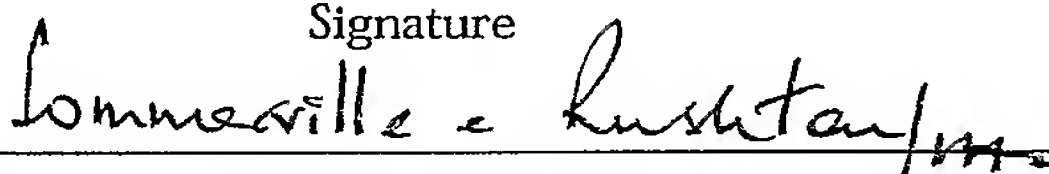
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18 March 2004

12. Name and daytime telephone number of person to contact in the United Kingdom  
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01727 854215

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## HIGH PRESSURE PUMPING APPARATUS AND METHODS

### Field of the Invention

5 The present application relates to methods and apparatus for producing pressure. It is particularly applicable, but in no way limited, to high pressure pumps and pressure intensifiers. It is particularly applicable to applications where an apparatus is required which is easy to maintain and which is hygienic.

### Background to the Invention

10 Flowable substances, such as liquid food products, may be treated by exposure to ultrahigh-pressures. For example, liquid food products may be preserved or otherwise chemically or physically altered after exposure to ultrahigh-pressures. In one conventional process, the food substance is loaded into a pressure vessel where it is pressurized to a selected pressure for a selected period  
15 of time to achieve the desired physical or chemical change. The vessel is then depressurised and the contents unloaded. The pressure vessel may then be reloaded with a new volume of unprocessed substance and the process may be repeated.

A variety of pumps and pressure intensifiers are known which can be used in  
20 this process. However, they all suffer from major disadvantages relating to ease of maintenance and hygiene. A typical prior art arrangement is shown in Figure O. This illustrates twin intensifiers of a design in which the component parts are connected together by screw-threaded connections. This is only one of a variety of constructional arrangements that the pressure components, or a frame holding the  
25 pressure components are held in place by screw threaded components. A further example is described in WO99/65341 (Flow International Corporation) which uses a yoke to hold the pressure components in place against the ultrahigh-pressures generated within the system when in operation. The components of the yoke are held together by screw-threaded components.

30 A major disadvantage of using screw threads in this application is that they are susceptible to thread galling. Galling can occur with a variety of metals, but particularly with stainless steel when a stainless steel oxide surface film breaks down as a result of direct metal contact. Solid-phase welding can then take place (whereby material is transferred from one surface to another). The symptoms of  
35 galling include surface damage and seizing and freezing up of equipment. Galling



commonly occurs when using stainless steel nuts and bolts together, where the contact points are subjected to high tightening torques.

Thread galling seems to be most prevalent with fasteners made of stainless steel, aluminium, titanium, and other alloys which self-generate an oxide surface film for corrosion protection. During fastener tightening, as pressure builds between the contacting and sliding thread surfaces, protective oxides are broken, possibly wiped off, and interface metal high points shear or lock together. This cumulative clogging-shearing-locking action causes increasing adhesion. In the extreme circumstances, galling leads to seizing – the actual freezing together of the threads. If tightening is continued, the fastener can be twisted off or its threads ripped out.

A number of ways of reducing thread galling have been suggested. Lubricating the internal and/or external threads can reduce galling, but this may be impractical in food or pharmaceutical applications because of the potential for product contamination. Using different stainless alloy grades for the bolt and the nut components also reduces galling. However, under the ultrahigh-pressures generated in systems according to the present invention, galling remains a serious problem. It is particularly serious in applications where frequent strip downs for cleaning and seal changes are required.

This leads on to the second problem, being ease of maintenance and cleaning. This is a particular problem in food and pharmaceutical applications. Pressure intensifiers known in the art, such as those described above, have to be stripped down almost entirely to clean them. That is to say, the screw threads must be completely undone and the components have to be disassembled and separated from the unit to be cleaned, and seals replaced. Furthermore, there is no provision for sterilising the components immediately prior to assembly. The result is that cleaning and maintenance activities are time consuming and costly and can result in significant down time. It is an object of the present invention to overcome, or at least mitigate, some or all of the problems outlined above.

### 30 Summary of the Invention

According to a first aspect of the present invention there is provided a pressure intensifier assembly comprising:-

- (i) a high-pressure barrel assembly;
- (ii) pressurising means;
- 35 (iii) a first and a second end closure assembly;

- (iv) a tension frame assembly adapted to resist axial load exerted, in use, along the longitudinal axis of the high-pressure barrel assembly; characterised in that the intensifier assembly further comprises at least one clamping piston adapted to preload the end closure(s) and the high-pressure barrel assembly against the tension frame assembly in order to overbalance anticipated internal end loads.

This arrangement has the advantage that no screw thread fixings are required within or associated with the tension frame or the pressure components. There are therefore no screw threads, and consequently no possibility of thread galling during disassembly or assembly.

Preferably the tension frame assembly takes the form of a yoke.

Preferably the assembly further comprises a first and a second high pressure seal assembly, said seal assemblies being located at either end of the high-pressure barrel assembly.

Preferably said pressurising means comprises a hydraulic ram assembly.

Preferably the assembly further comprises a stand.

In a particularly preferred embodiment the high-pressure barrel assembly is detachably mountable from the intensifier assembly without the need to undo a screw thread. This novel arrangement is possible as a direct result of using a clamping piston to pre-load the end closures. Removal of the pressure and withdrawal of the clamping piston allows the high-pressure barrel to be removed simply and easily.

Preferably at least one end closure is retractable and, once retracted, the assembly is adapted such that the pressure barrel assembly becomes detachable from the intensifier assembly.

In a particularly preferred embodiment said assembly further comprises a high-pressure barrel assembly lifting means.

Preferably the high-pressure barrel assembly is pivotally mounted with respect to the stand.

30

#### Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the following drawings wherein:-

Figure O illustrates a cross-sectional view of a prior art pressure intensifier in which the pressure components are held together by screw threads;

35



Figure 1 illustrates diagrammatic front and side elevations of a pressure intensifier assembly showing the key components according to a first embodiment;

Figure 2 illustrates the pressure intensifier assembly of Figure 1 in a so-called maintenance configuration;

5 Figure 3 illustrates a pressure intensifier assembly of the first embodiment including additional operating components;

Figure 4 illustrates an embodiment which incorporates shield facilitate steam sterilisation;

10 Figure 5 illustrates side and top elevations of a further embodiment showing a single intensifier assembly in a horizontal orientation.

#### Detailed Description of the Preferred Embodiments

The present invention will now be described by way of example only. These examples represent the best ways known to the applicant of putting the invention  
15 into practice, but they are not the only ways this can be done.

The present invention relates to apparatus for producing high pressures, to pressure intensifiers, to apparatus for pressure-processing substances such as food products and to their methods of use and maintenance.

Figure O shows a typical twin intensifier arrangement of conventional design,  
20 which does NOT incorporate the claimed invention but is commonly used in currently existing systems; in industrial plant, and in laboratories where appropriate levels of pressures are required. In this context the term "pressure intensifier" is intended to encompass any apparatus wherein means are provided for pressure multiplication in a working chamber in order to amplify the total pressure supplied to  
25 a platen (eg pressure multiplication sleeve, pressure accumulator). The working chamber which provides the pressure multiplication feature may be separate from the working chamber in direct contact with the platen.

The intensifier assemblies 10 in Figure O depend upon screw threads 11,12 to retain the principal components and to resist the substantial forces exerted upon  
30 the end closures 13,14 and the central attachment body 15, which connects the high-pressure barrel 16 to the lower pressure drive assembly 17. Maintenance of these intensifiers requires heavy engineering tools as well as considerable manual effort in order to release the threads and to separate the major components just to gain access to the working seals 19,20, which require regular replacement,  
35 especially at the higher end of application pressure range, which may require pressures in the order of 1000 Mpa. (approximately = 150,000lb per square inch).

The end closures and centre section retentions are all screw threads requiring engineering tools such as "tommy bars" and spanners for any internal maintenance to take place.

Thread galling, as described above, is inevitably a problem from time to time with this type of assembly, which is a further complication to this type of assembly.

It will also be appreciated that during disassembly the individual components must be lifted manually and put to one side. Where large intensifiers are involved this can create Health and Safety problems and may well limit the physical size of the unit.

A preferred embodiment of the present invention is shown in Figure 1 in front and side elevation. The intensifier 30 of the present invention consists of a tension frame assembly 31 within which are located the key pressure generating components. This example illustrates a twin barrel arrangement but it is applicable to one or a plurality of barrel arrangements. In this context, and for the avoidance of any doubt, the term "plurality" has the meaning one or more.

The intensifier arrangement shown in Figure 1 and described in this and other embodiments may be used for a wide variety of high pressure applications, including use for high pressure gases as well as liquid fluids.

In this example the tension frame assembly is shown as an elongate yoke. However, this is not the only form which the tension frame can take. A wide variety of physical arrangements are possible, including a non-continuous frame, ie a frame which does not substantially entirely surround the pressure generating components. A yoke as illustrated has proven to be a simple and effective arrangement and, as such, is one of the preferred embodiments.

The pressure generating components include a high pressure barrel assembly 32 and a pressurising means 33 which includes a hydraulic drive piston 34 and high pressure ram 35 associated with a drive pressure cylinder 38. Top 36 and bottom 37 closure seals are provided associated with top and bottom end closure means. Thus far the components and their assembly is of generally conventional design and of a type known per se. However, part of the novelty of this arrangement lies in the incorporation of a clamping piston means which reacts against the longitudinal tension frame to exert a resilient axial force, which pre-loads the end closures and the central barrel abutments to overbalance any anticipated internal end-loads.

This arrangement brings with it a number of advantages. Firstly, no screw-threaded connections of any kind are required to secure the pressure components in

place in use. Thus thread galling is not, and can never be, a problem during disassembly/assembly. Secondly, by applying an over-compensating force any elastic movement/deformation in the tension frame can easily be accommodated and the closure seals will remain intact and effective. Thirdly, and importantly, by withdrawing the clamping piston towards the tension frame sufficient space is automatically created to enable the high-pressure barrel to be withdrawn for cleaning, maintenance and seal replacement. This arrangement is shown more clearly in Figure 2.

Figure 2, in which a numbering system corresponding to Figure 1 has been used, shows a preferred method of retracting the clamping pistons and manipulating the barrel assembly to gain free access for replacing the high-pressure seals. Moreover, with simple automation, the barrel assembly may be automatically manipulated into the position for easy maintenance and repositioned and clamped with interlocks for safe operation at pressure.

The tension frame 31 is mounted on a stand 40. Also mounted on the stand 40 is a barrel lifting means generally shown as 41. In this example the barrel is pivotally mounted with respect to the stand by a swing column 42. It should be understood that in this context the term "pivotally mounted" has a broad meaning and is intended to encompass any arrangement whereby the barrel may swing out of the longitudinal plane of the tension frame. It does require or imply the presence of a true pivot point as shown in Figure 2, although this is one convenient arrangement.

It will be appreciated that the drive pressure assembly 38 simply sits on the bottom of the tension frame in this arrangement and it too may be lifted out for cleaning and maintenance if required.

By incorporating a barrel-lifting ram 43 into the swing column the barrel may be lifted clear of the lower ram seal assembly 44 and then swung out of line of the tension frame.

Assembly, once seals have been replaced and any cleaning and maintenance has been done, is a reversal of the above process.

Using an arrangement whereby the barrel pivots out of the general longitudinal axis of the assembly is only one of a variety of arrangements which are possible. The barrel, or the tension frame for that matter, could move sideways or up or down, with respect to each other depending on the orientation of the unit.

Figure 3 shows an extension of the claimed invention in which the twin intensifiers are required to pump liquids for the purpose of homogenisation. An

essential requirement for this application is that all components, which come in contact with the process products are hygienically clean. The ability to open the assembly to clean all wetted component surfaces with sterile cleaning agents is a major advantage of the design according to the claimed invention.

5           Positive closing power operated valves 60 may be optionally fitted and synchronised with the stroking of the intensifiers in order to improve the reliability of flow control. This provides for a level of performance over and above the more commonly used spring loaded check valves. The use of such positive valving is especially beneficial when pumping suspended solids in fluids where the suspended  
10 materials can clog or otherwise impair the operation of spring loaded check valves.

It will also be appreciated from Figure 3 that the body of the drive pressure cylinder has been extended. The extended central body 62 houses the length of the ram not allowed to enter the processing chamber.

15           It will be appreciated that this type of intensifier can be applied to homogenising and cell rupture machines which may be used to pump various liquids and fluid suspensions at high pressure through a homogenising valve or orifice or other constricting device in order to emulsify, activate or inactivate materials for numerous processes and purposes.

20           Figure 4 shows a further aspect of the invention which is a refinement to the hygienic application. A cylindrical shield 70 is provided and this shield is designed and adapted to be moved into the position shown whilst the barrels and caps are separated to provide an enclosed passage for steam sterilisation to be carried out.

25           The assembly may be closed with the shields remaining in place to prevent vital surfaces being exposed to the environment. Thus, in the semi-closed position, where the barrel assembly is in the vertical axial position within the frame, but still lifted above the seal carrier, the clamping pistons remain retracted so that the space exists below and above the high-pressure barrel blocks. Cylindrical sleeves 70, which would normally be parked in readiness, may be lifted into position to shield the open gaps. Also, the high-pressure ram is moved specially into the raised  
30 position for the purpose. High or low-pressure steam may be injected through the chambers in order to achieve ultimate sterilisation of all the important surfaces. Provision is made for the assembly to be closed with the cylindrical shields being lowered down to their normally parked position once assembly is completed, so that the sterilised surfaces remain protected from environmental contact both during and  
35 after the sterilisation process.

Figure 5 shows a single intensifier variation of the claimed invention in which the whole assembly is optionally horizontally mounted which would have advantages for smaller laboratory applications where bench top location is preferred. The components in this single, horizontal version correspond to those described in Figures 1 to 4 above and are numbered correspondingly. The barrel-lifting ram 143 in this embodiment lifts upwards, out of the horizontal plane of the tension frame.



Claims:

1. A pressure intensifier assembly comprising:-
  - (i) a high-pressure barrel assembly;
  - 5 (ii) pressurising means;
  - (iii) a first and a second end closure assembly;
  - (iv) a tension frame assembly adapted to resist axial load exerted, in use, along the longitudinal axis of the high-pressure barrel assembly;

characterised in that the intensifier assembly further comprises at least one

10 clamping piston adapted to preload the end closure(s) and the high-pressure barrel assembly against the tension frame assembly in order to overbalance anticipated internal end loads.
2. A pressure intensifier assembly as claimed in any preceding claim wherein
 

15 the tension frame assembly takes the form of a yoke.
3. A pressure intensifier assembly as claimed in any preceding claim wherein the assembly further comprises a first and a second high pressure seal assembly, said seal assemblies being located at either end of the high-pressure barrel
 

20 assembly.
4. A pressure intensifier assembly as claimed in any preceding claim wherein said pressurising means comprises a hydraulic ram assembly.
- 25 5. A pressure intensifier assembly as claimed in any preceding claim wherein the assembly further comprises a stand.
6. A pressure intensifier assembly as claimed in any preceding claim wherein the high-pressure barrel assembly is detachably mountable from the intensifier
 

30 assembly.
7. A pressure intensifier assembly as claimed in Claim 7 wherein the high-pressure barrel assembly is detachable from the intensifier assembly without the need to undo a screw thread.



8. A pressure intensifier assembly as claimed in any one of Claim 7 or Claim 8 wherein at least one end closure is retractable and, once retracted, the assembly is adapted such that the pressure barrel assembly becomes detachable from the intensifier assembly.

5

9. A pressure intensifier assembly as claimed in any of Claims 7 to 9 inclusive wherein said assembly further comprises a high-pressure barrel assembly lifting means.

10 10. A pressure intensifier assembly as claimed in any one of Claims 7 to 10 inclusive when dependent on Claim 6 wherein the high-pressure barrel assembly is pivotally mounted with respect to the stand.

**ABSTRACT****HIGH PRESSURE PUMPING APPARATUS AND METHODS**

- 5           A pressure intensifier assembly comprising:-
- (i)   a high-pressure barrel assembly;
  - (ii)   pressurising means;
  - (iii)   a first and a second end closure assembly;
  - (iv)   a tension frame assembly adapted to resist axial load exerted, in use, along
- 10           the longitudinal axis of the high-pressure barrel assembly;
- characterised in that the intensifier assembly further comprises at least one clamping piston adapted to preload the end closure(s) and the high-pressure barrel assembly against the tension frame assembly in order to overbalance anticipated internal end loads.

15



CONVENTIONAL INTENSIFIER CONSTRUCTION,  
 NOTE:- END CLOSURES AND CENTRE SECTION  
 RETENTIONS ARE ALL SCREW THREADS REQUIRING  
 ENGINEERING TOOLS SUCH AS "TOMMY BARS" AND  
 SPANNERS FOR ALL INTERNAL MAINTENANCE  
 WORK.

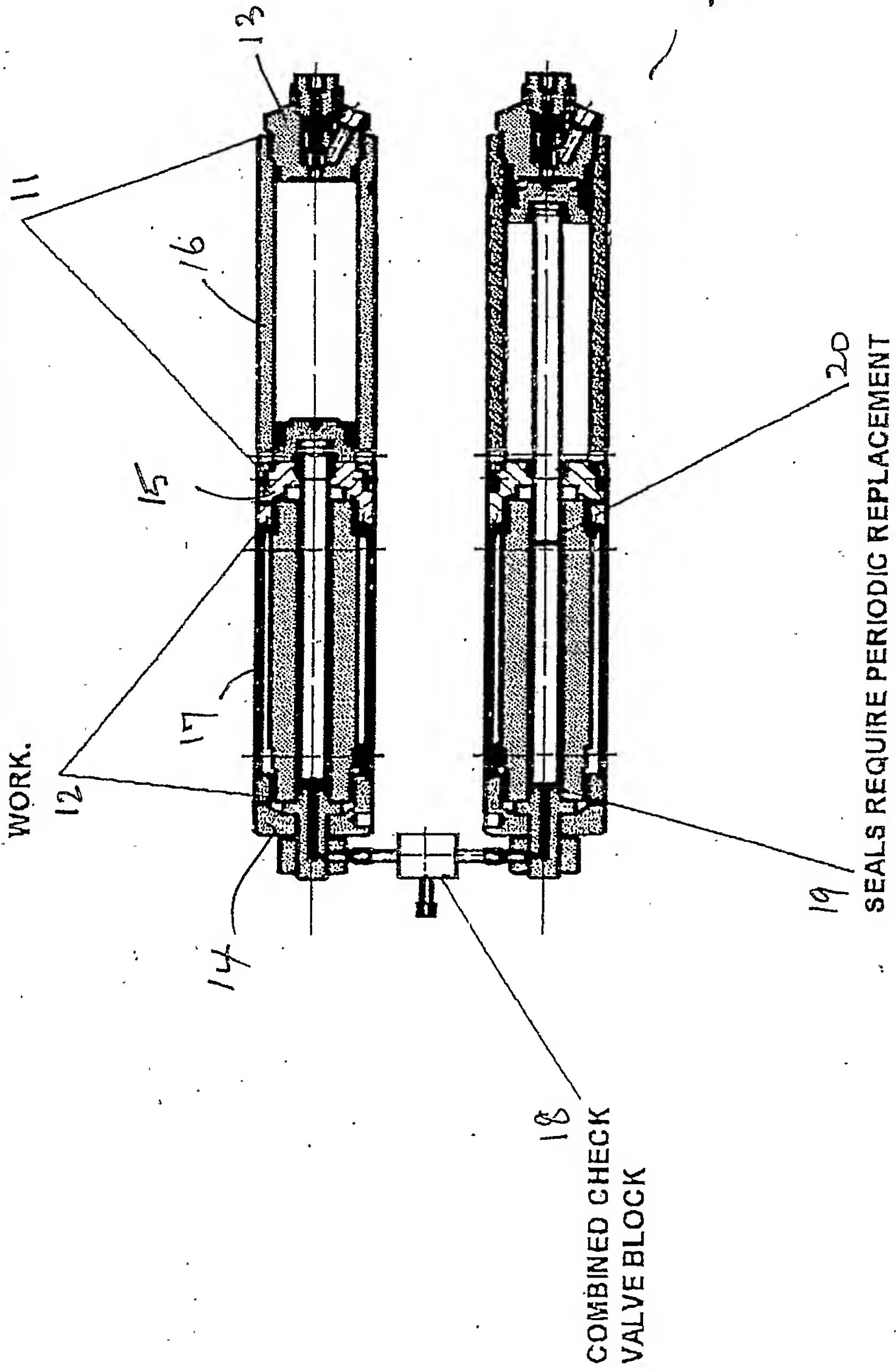


FIG. 0



ARRANGEMENT FOR  
LIFTING THE CLAMPING  
PISTONS IN ORDER TO  
RAISE THE CAPS AND  
SEPARATE THE BARREL  
ASSEMBLY

CLAMPING PISTONS

LONGITUDINAL  
TENSION FRAME

INLET AND OUTLET, SPRING LOADED  
CHECK VALVES BUILT INTO  
TOP CLOSURE

HIGH PRESSURE  
BARRELS

REPLACEABLE  
RAM SEAL  
ASSEMBLY

REPLACEABLE  
TOP SEAL

FIG 1A

30

STAND

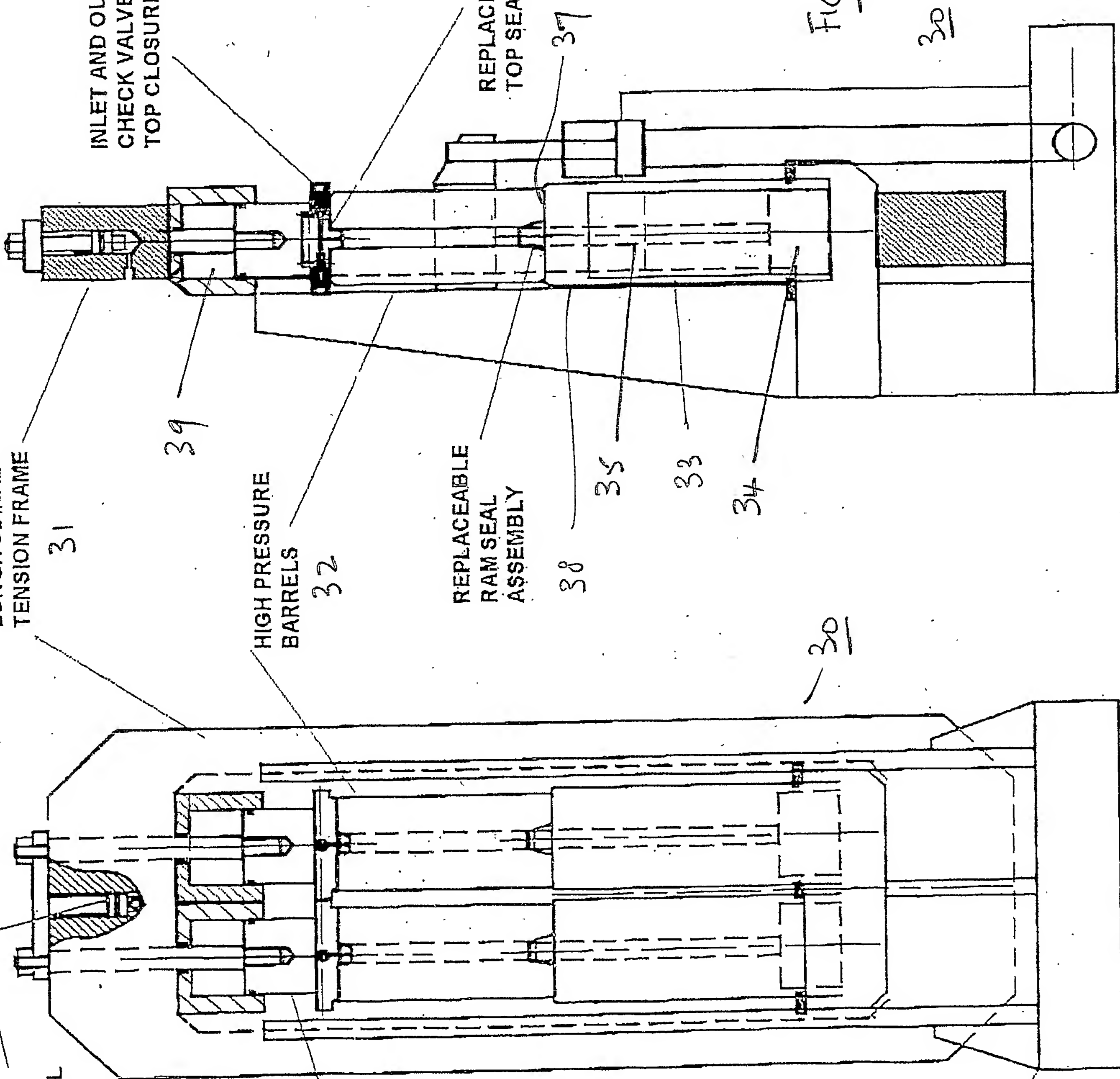
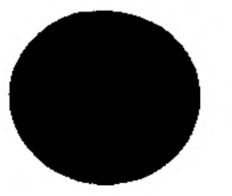


FIG 1B

30

FIG. 1





CLAMPING PISTONS SHOWN IN  
RETRACTED POSITION TO PROVIDE  
SEPARATION CLEARANCE FOR HIGH  
PRESSURE BARRELS.

LONGITUDINAL  
TENSION FRAME

31

REPLACEABLE TOP  
SEAL

HIGH PRESSURE BARRELS  
SHOWN LOCATED OUT OF FRAME  
PROVIDING ACCESS FOR SEAL  
MAINTENANCE AND CLEANING

HIGH PRESSURE  
BARRELS

REPLACEABLE  
RAM SEAL  
ASSEMBLY

44

BARREL LIFT TO CLEAR  
RAM SEAL ASSEMBLY  
ON SEPARATION

43

INTENSIFIER RAM  
& PRIMARY DRIVE  
PRESSURE PISTON

34

STAND

40

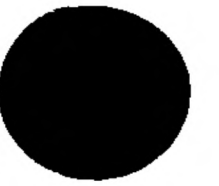
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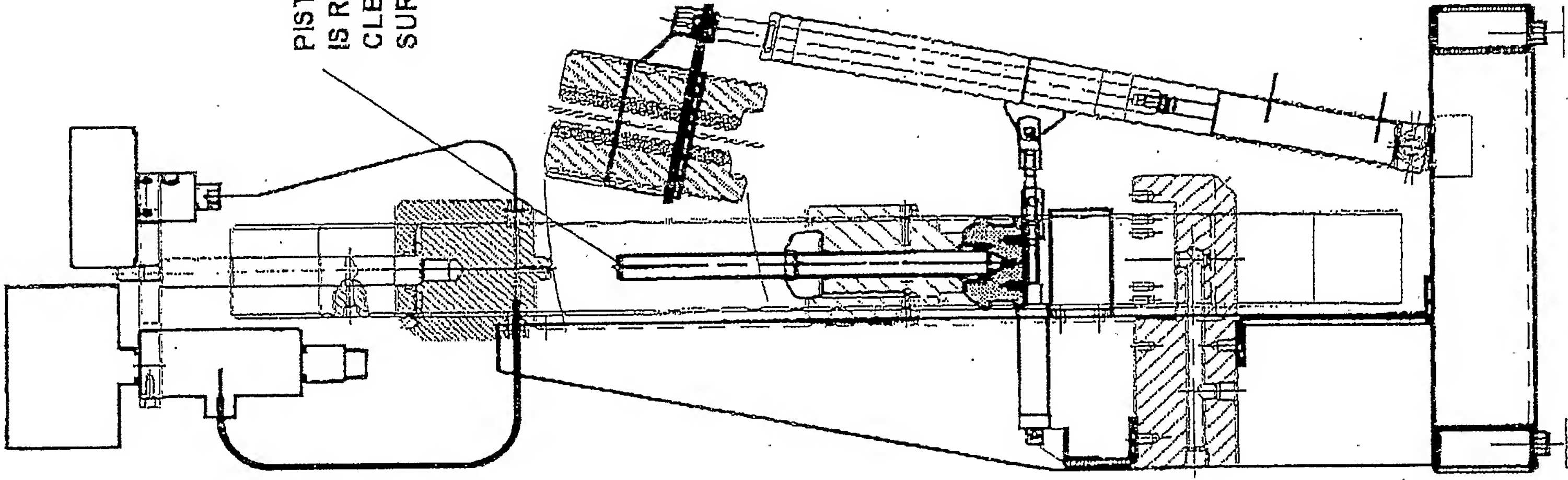
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FIG. 2

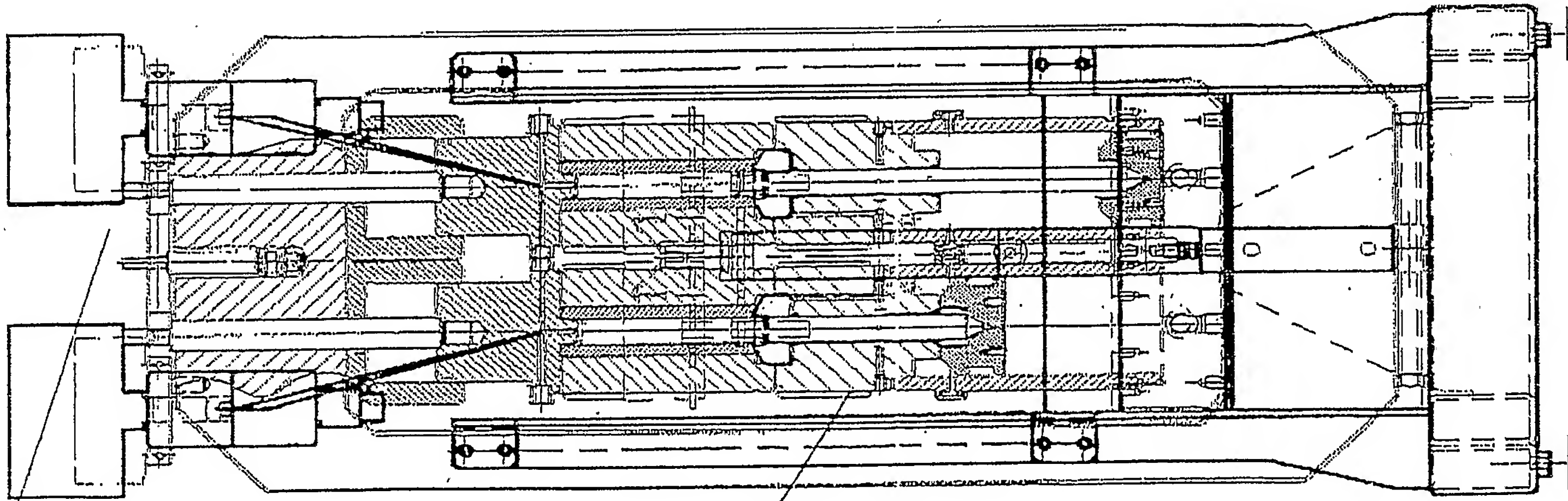
2/6



4/6



PISTON & RAM ASSEMBLY  
IS RAISED TO FACILITATE  
CLEANING THE "WETTED"  
SURFACE OF THE RAMS



60  
SITIVE CLOSING POWER OPERATED VALVES  
Y BE OPTIONALLY FITTED AND  
NCHRONISED WITH THE STROKING OF THE  
ENSIFIERS IN ORDER TO IMPROVE THE  
LIABILITY OF FLOW CONTROL  
RFORMANCE OVER AND ABOVE THE MORE  
MMONLY USED SPRING LOADED CHECK  
LVES.

E USE OF SUCH POSITIVE VALVING IS  
PECIALLY BENEFICIAL WHEN PUMPING  
SPENDED SOLIDS IN FLUIDS WHERE THE  
SPENDED MATERIALS CAN CLOG OR  
HERWISE IMPAIR THE OPERATION OF  
RING LOADED CHECK VALVES.

TENDED CENTRAL BODY HOUSES THE  
NGTH OF THE RAM NOT ALLOWED TO  
TER THE PROCESSING CHAMBER.

62

WIN SYNCHRONISED STROKING PRESSURE  
TENSIFIERS BEING A SIMILAR  
RRANGEMENT TO THAT SHOWN IN FIG.1  
ND FIG.2, BUT IN THIS CASE APPLIED TO A  
OMOGENISING MACHINE WHICH MAY BE  
SED TO PUMP VARIOUS LIQUIDS AND FLUID  
USPENSIONS AT HIGH PRESSURE  
THROUGH A HOMOGENISING VALVE IN  
ORDER TO EMULSIFY OR REFINE MATERIALS  
OR NUMEROUS PROCESSES AND  
URPOSES.

FIG. 3



5/6

CYLINDRICAL SHIELDS MAY BE MOVED INTO POSITION WHILST THE BARRELS AND CAPS ARE SEPARATED TO PROVIDE AN ENCLOSED PASSAGE FOR STEAM STERILISATION TO BE CARRIED OUT. THE ASSEMBLY MAY BE CLOSED WITH THE SHIELDS REMAINING IN PLACE TO PREVENT VITAL SURFACES BEING EXPOSED TO THE ENVIRONMENT.

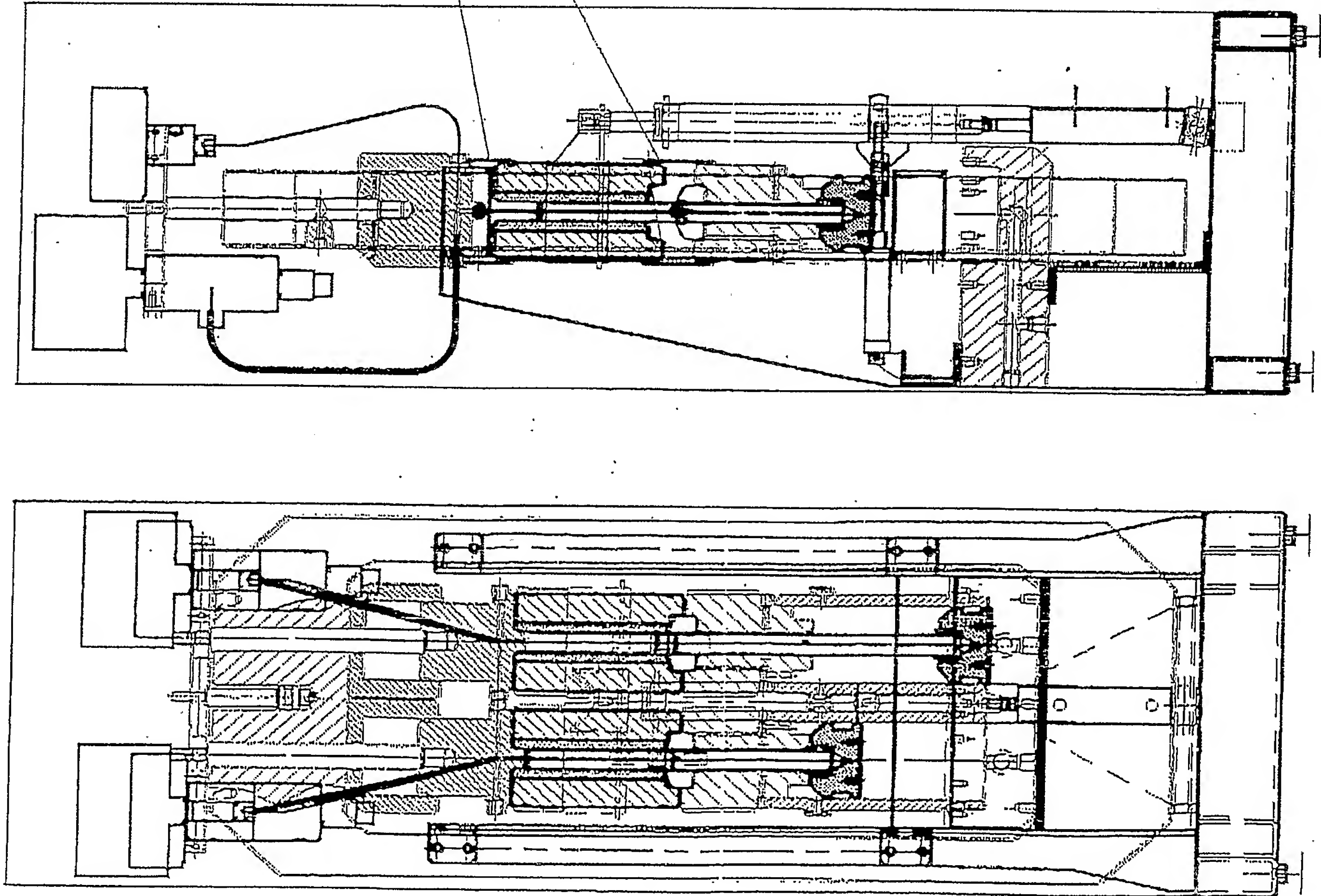
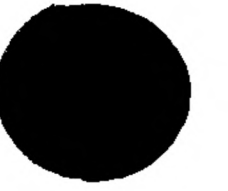


FIG.4





SINGLE INTENSIFIER ARRANGEMENT SHOWN IN THE OPTIONAL HORIZONTAL ORIENTATION, WHICH MAY BE REGARDED AS MORE SUITABLE FOR A SMALL BENCH OPERATED LABORATORY SYSTEM.

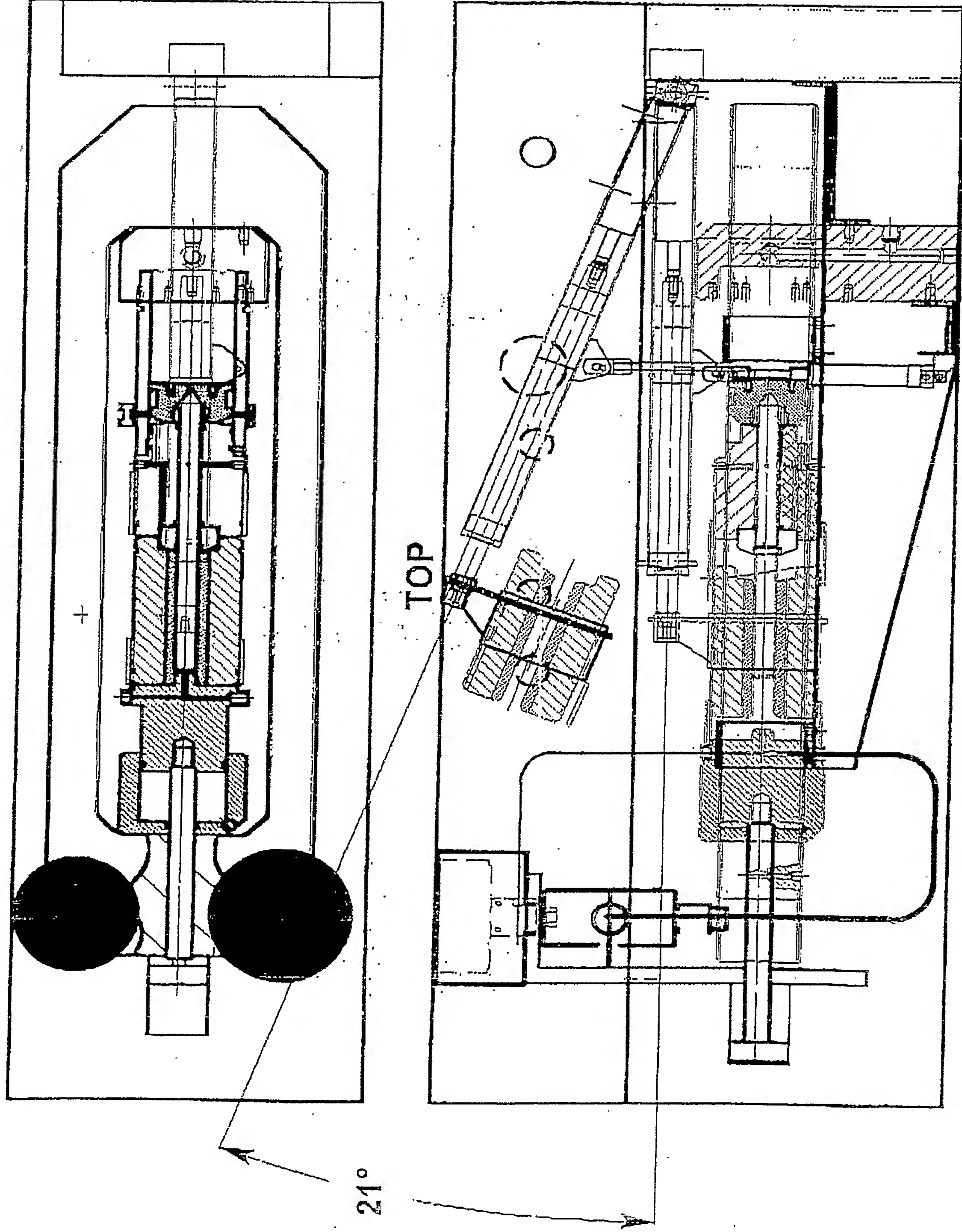


FIG. 5

